The Hinnant Prosthetics Quarterly

Experience Our Road to Prosthetic Excellence

Autumn 1998

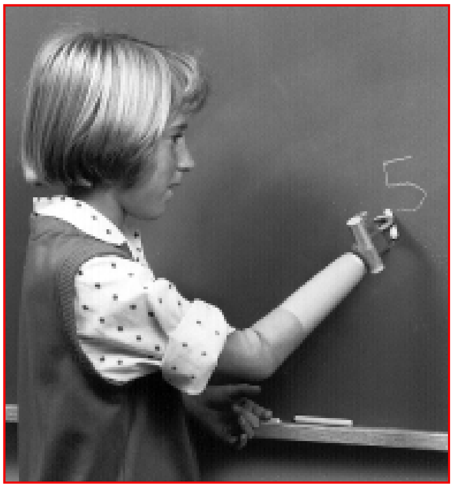
Solving the Upper-Extremity Enigma

Though an extensive array of components is available, ranging from relatively simple cosmetic devices to sophisticated myoelectric systems, it is estimated that 50 percent or less of the nearly 10,000 Americans who undergo upper-limb amputation each year achieve functional prosthetic success. Some are never fitted with a prosthesis; others leave theirs in a closet.

The reasons behind this paradox are numerous and complex, but recent research suggests better results are attainable.

Component Selection

The wide range of available upper-extremity systems and options is itself part of the problem. So many different combinations of suspension, power, design and control are now offered (see pages 2-3) that clinicians face increasing difficulty keeping abreast of their myriad advantages, limitations and applications. This factor is of considerable importance, for experience has shown close correlation between appropriate matching of componentry with genuine patient requirements and sustained successful use of the prosthesis.



A ready reference on the full range of upper-extremity systems and components is the well-qualified prosthetist. Today's prosthetist combines theoretical knowledge with technical skills and keeps abreast of newly developed concepts and hardware, and therefore is a vital resource for prosthesis prescription.

Needs/Capabilities Analysis

Ascertaining a patient's bona fide rehabilitation needs and desires, which may be quite different from his or her stated requirements or those of his family, is another prime determinant of prosthetic success in the upper-extremity amputee. This process requires careful analysis of both tangible and intangible factors:

★ Function. What combination of control (body-powered vs. myoelectric) and terminal device (hook vs. hand) will best provide for the patient's vocational and leisure activities?

★ Patient "prosthetic physical fitness." Key factors include weight tolerance, skin condition surrounding the amputation site, electromyographic strength and general state of health.

★ Time since amputation. A major determinant of prosthetic success/failure.

★ Motivation of both patient and family to attain prosthetic success. For some, cosmetic restoration is quite sufficient.

★ Body image. Can the patient accept a new self-image that includes using a prosthesis in public?

★ Expectations, either too high or too low, can lead to failure.

Trial Prosthesis (IPOP)

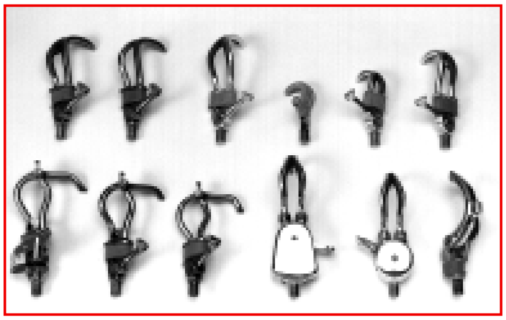
Assuming other considerations indicate a new upper-limb amputee is capable of success given the appropriate system, the timing of initial prosthetic fitting may well spell the difference between successful and marginal rehabilitation.

(Continued on page 4)

The Fascinating Practice of Upper

Restoration of manipulation and grasping functions lost to upper-limb amputation (or creating those abilities where none previously existed in the case of congenital defect) is one of the most fascinating — and challenging — aspects of rehabilitative medicine.

Fabrication of functional hand prostheses dates back at least to iron devices fashioned for ill-starred knights of the early 15th century. However, the most dramatic progress in upper-limb prosthetic design has occurred since the end of World War II, including development of sophisticated externally powered/myoelectrically controlled "bionic" systems. These cutting-edge devices are now being successfully used in many parts of the country, though conventional prostheses remain the devices of choice. An estimated 90 percent of all functional upper-limb systems in use today are body-powered.



Selection of hook terminal devices

Terminal Devices

Aside from those amputees whose sole objective is cosmetic restoration, the primary motivation for wearing an upper-limb prosthesis is to regain the lost hand's prehensile functions — holding, carrying, and manipulating.

Except for partial hand devices, which take advantage of a certain degree of retained prehension capability, all upper-extremity prostheses involve some form of hand substitute or terminal device, broadly classified into "hands" and "hooks." Approximately two-thirds of amputees in the U.S. use hook devices.

Hand components are more cosmetically pleasing but as a rule are less functional than hooks. They are also heavier and less durable. Hands may be either voluntary-opening or voluntary-closing, utilizing either relative body motion or external power to overcome static elastic force. Many options, ranging from relatively inexpensive passive models to intricate electrically actuated systems, are available.

Split hooks come in many different configurations and sizes, including models designed for heavy-duty vocational activities. In general, hooks permit better visibility of prosthesis movement than hand devices, an important functional consideration given the absence of normal sensory (touch) feedback.

In recent years, a new generation of terminal devices has appeared, focusing on the special requirements of athletes and outdoor enthusiasts, notably golfers, cyclists, fishermen, and ball players of all types. Active amputees may in fact use several terminal devices matched to their varying activities; all devices manufactured in the U.S. use a standard mounting stud for mating with the prosthetic forearm and thus are readily interchangeable.

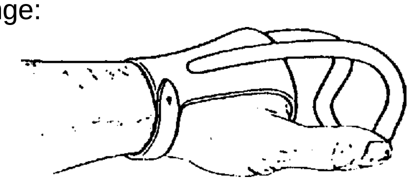
Suspension

Upper-limb prostheses are usually suspended by a combination of close socket fit and a strategically positioned upper-body harness, which in body-powered systems also anchors the cable providing power and control to the terminal device. Design and construction of the harness vary with the amputation level and the build and capabilities of the patient.

The socket serves as interface between the residual limb and prosthesis and must protect the soft skin around the amputation site as well as provide a firm attachment point. Sockets are generally made of plastic laminate or thermoplastic formed over a positive model of the residual limb.

Conventional Systems

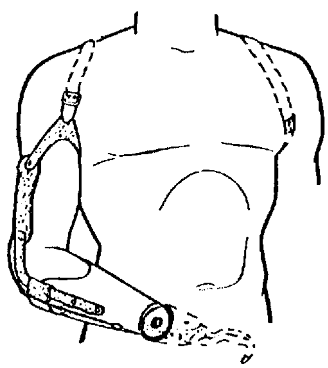
Each amputation level presents different prosthetic challenges; in general, the higher the level, the tougher the challenge:



Custom partial hand prosthesis

Partial-hand — Because any retained prehensile capability and sensation are preferable to the best prosthesis, surgeons normally seek to retain even the slightest functional part of the hand whenever possible. Partial-hand prostheses are usually designed to (1) provide opposition for one or more residual digits or segments and/or (2) restore cosmetic wholeness. Each prosthesis is custom-designed and fabricated to the needs of the particular patient.

Below-elbow (BE) — Prostheses for amputation levels between the wrist and elbow are generally single-control systems, which use a stainless steel cable actuated by shoulder motion on the amputated side to open or close a terminal device (see diagram). Most BE systems use a figure-eight harness design.

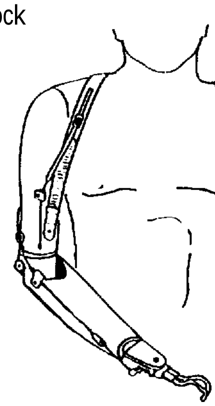


Below-elbow prosthesis

Above-elbow (AE) — The addition of an elbow joint adds to the complexity of the

-Extremity Prosthetics

prosthesis. The most common approach is to incorporate a second, independent control cable to lock and unlock the elbow unit. In such an arrangement, movement of the primary cable while the elbow is unlocked generates elbow flexion/extension. Once the lock is actuated by secondary cable action, further primary cable travel is transferred to actuate the terminal device.



Conventional AE system

Shoulder/Forequarter — In the absence of upper arm movement to help control the prosthesis, functional restoration for this amputation level is rather difficult but certainly possible for the well-motivated individual. Although a harness-operated shoulder joint is not yet available, manual components do permit passive shoulder movement. Prosthesis design at this level is very individualized.

Bilateral — Other than having two independent systems to deal with, the only major additional hurdle faced by bilateral upper-limb amputees is the complete absence of sensory feedback for prehensile activity. For ease of donning and overall comfort, a single harness that controls both systems is generally preferred over two. In most cases, the more functional hook-type terminal device is used.

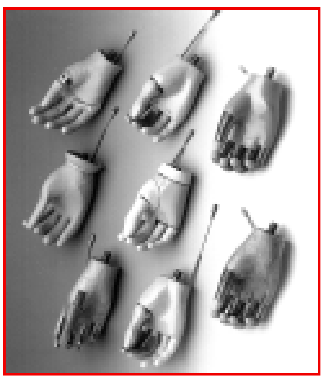
Externally Powered Systems

While early attempts at harnessing an external power source to control a hand prosthesis date back at least to 1915, it was not until the refinement of myoelectric technology in the past 25 years that this approach has become practical. With a myoelectric system, the amputee controls the action of a battery-powered terminal device, possibly in conjunction with a wrist rotator and/or elbow flexion unit, using electromyographic (EMG) potentials generated by muscle contraction in the residual limb.

A primary advantage of the myoelectric prosthesis is that an external cable is no longer necessary, eliminating gross body motions for terminal device operations. A harness is still necessary for suspension of above-elbow systems. Moreover, the pinch force of a myoelectric hand or hook is significantly greater than that of a cable-powered device. Also under evaluation are hybrid systems combining a myoelectric terminal device with a conventional elbow.

Pediatric Systems

Experience shows that children who are fitted with a prosthesis at an early age exhibit the greatest potential for success. A passive prosthesis can usually be introduced when the child is able to sit alone (about age six months) and a body-powered system with the advent of muscular coordination (2-3 years).



Hand terminal devices

Most upper-extremity components and terminal devices come in children's sizes, and myoelectric systems for young patients are also offered. Training is generally more difficult in children, but with solid parental support they can become proficient with their prosthesis in a relatively short time. From then on, children typically become more adept with their prosthesis than comparably fitted adults.

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For answers to specific questions about upper-extremity prosthetics, please call the Hinnant office nearest you.

The Reading Shelf

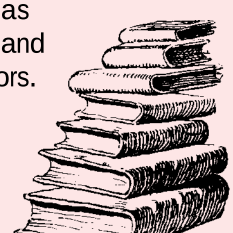
For More Information On Upper-Limb Prosthetics...

Regrettably, space limitations preclude a more-thorough treatment of the fascinating topic of upper-limb prosthetics. However, more-thorough treatment of upper-limb amputation and prosthetic rehabilitation is readily available through three excellent publications:

The **Atlas of Limb Prosthetics, Surgical and Prosthetic Principles** is a highly detailed volume from the American Academy of Orthopaedic Surgeons. It is well-illustrated and provides in-depth coverage of amputation techniques and prosthetic components. 668 pages. Order from: The C. V. Mosby Co., 11830 Westline Industrial Dr., St. Louis, MO 63146.

Limb Prosthetics, 6th Edition by A. Bennett Wilson Jr. offers a somewhat less-technical approach, which is ideal for anyone seeking a solid introduction to prosthetic management. 122 pages. Order from: Demos Publications, 156 Fifth Ave., New York, NY 10010.

Comprehensive Management of the Upper-Limb Amputee, co-edited by occupational therapist Diane Atkins and physiatrist Robert Meyer, provides excellent treatment of prosthetic componentry, notably myoelectric systems, as well as amputee training and psychological factors. 260 pages. Order from: Springer-Verlag, 175 Fifth Ave., New York, NY 10010.



Keys to Upper-Limb Prosthetic Success

(Continued from page 1)
Research shows the longer an amputee has to adjust to the idea of being one-handed, the less willing he or she is to put forth the effort necessary to learn how to use a prosthesis, no matter how simple or advanced it may be.

If a patient can be introduced to a prosthesis soon after surgery, not only will he or she be more likely to achieve ultimate success with a functional system, but many of the other factors listed above can be more readily assessed as well. In the process, the rehab team will gain added insight into the best combination of components for that individual.

While the patient's final prosthesis may take weeks to design and fabricate, an immediate post-operative prosthesis (IPOP) provided within a few days of surgery can help the new amputee develop a positive psychological mindset to prosthetic use before resignation or despair sets in.

A temporary socket made of easily fabricated thermoplastic materials, fiberglass casting tape, etc. will enable the new amputee to experiment with different types of components as the rehab team evaluates his or her prosthetic potential. This opportunity for early training and evaluation helps new amputees realize their capabilities, improves prospects for ultimate success, and in some cases precludes expenditure for a sophisticated system that will ultimately go unused.

The Clinical Team

Statistical evidence validates the effectiveness of the multidisciplinary rehab team in achieving upper-extremity prosthetic success. By fully applying their individual expertise to the patient's restoration effort, team members contribute to a synergistic process that probably offers the best chance for optimum results. Though the surgeon's technical role after amputation is limited, his leadership and support for the team effort are essential for success. A physiatrist may also play a vital role on the team. The prosthetist provides componentry knowledge as well as design, fabrication, fitting and alignment skills. The physical therapist plays an important role in residual limb care, training, and evaluation of patient capabilities. In many cases, an occupational therapist assumes the primary responsibility for prosthetic training.

Other team members may include a psychologist, nurse, vocational counselor, social worker, amputee clinic coordinator and members of the patient's family. Of course, the most important member of the rehab team is the patient. Without his or her willing involvement, the work of the others on the team becomes superfluous.

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With due consideration and appropriate utilization of these "prosthetic success factors," those responsible for directing the care of upper-limb amputees can maximize their patients' opportunity to achieve the functional and psychological restoration of which they are capable.

New Plan Affiliations

Hinnant Prosthetics proudly announces our selection to provide prosthetic services for Charlotte-area members of insurance plans participating in the National Provider Network. We are pleased to welcome plan members of:

Advantage Administrators • American International Life
Anchor Benefit Corporation • Babb Inc. • Benefit Planning Services Inc.
Corporate Health Administrators • Coresource • E.B. Morris
Employee Sponsored Plans • Golden Rule • Jefferson Pilot
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